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FIGHTING VEHICLES

RESEARCH AND DEVELOPMENT

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RESEARCH DIVISION

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REPORT NO TR 7.

FIRING TRIALS

INVENTORY 1971

WITH THE 120MM. TANK GUN IN
CONQUEROR, F.V.214,
USING

INV 90

A.P.D.S./T. SHOT (LANOLINE TREATED)
AND H.E.S. SHELL
IN ALL STAGES OF LIFE

17616-57-001

PICATINNY ARSENAL
TECHNICAL REGISTRATION SECTION

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Chobham Lane,
Chertsey,
Surrey

USASGUK
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February
1957

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I. Wieland, C. J.

II. Engine F.V. 214/FV 1E.

III. F.V. 214.

IV. HES shell.

V. APDS slats.

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FIGHTING VEHICLES RESEARCH AND DEVELOPMENT ESTABLISHMENT. MB.

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RESEARCH DIVISION

TRIALS GROUP REPORT

ON

FIRING TRIALS WITH THE 120 M.M. TANK GUN MOUNTED
IN CONQUEROR F.V. 214 USING A.P.D.S./T. (LANOLINE-TREATED)
SHOT AND H.E.S. SHELL IN ALL STAGES OF GUN LIFE

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F.V.R.D.E. (Ascot 1160),
Chobham Lane, Chertsey.
20th February, 1957
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ABSTRACT

This report describes firings with a 120 m.m. tank gun mounted in Conqueror tank, using A.P.D.S./T. lanoline-treated shot and H.E.S. shell. Both types were fired series for series, starting with a new gun and continuing until the gun was shot-out. The information is under the following main headings:-

- (i) Dispersion at ranges of 1,000 yds., 1,500 yds. and 2,000 yds.
- (ii) Effects of barrel wear on drop of H.E.S. and probability of hitting.
- (iii) Flash-back and after-burn.
- (iv) Effects of wind and drift on H.E.S. shell.
- (v) Gun life and loss of muzzle velocity.

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ORIGIN This trial was initiated by the Research Trials Group under F.V.R.D.E. Project Sheet No. F.V.214/FV 1E.

1. INTRODUCTION

1.1 F.V.R.D.E. Report (No. A.R.145) described trials with the 120 m.m. gun mounted in "Conway" F.V.4004 to assess the accuracy of A.P.D.S./T. shot and H.E.S. shell when the propellant charge for both types was NQ/S.282-094 and NQ/S.134-040 respectively. The report showed that the accuracy of both types of ammunition was not affected until the wear of the barrel at 1" C. of R. exceeded 0.25"; this observation applied whether the projectile - either type - was case rammed or stick rammed during the loading operation.

1.2 Subsequent to these firings, the propellant charge for each type of ammunition has been changed (details of ammunition used in this trial are shown in Appendix 1) and in an attempt to reduce the dispersion of the A.P.D.S./T. shot, the "core" tapers have been treated with lanoline.

1.3 The trials reported herein were carried out in Conqueror, F.V.214, during the summer, 1956, at Kirkcudbright, to obtain information under the following headings:-

- (i) Dispersion of A.P.D.S./T. shot and H.E.S. shell against vertical targets at 1,000 yds., 1,500 yds. and 2,000 yds.
- (ii) Displacement of H.E.S. shell due to gun wear and the effects on the probability of hitting when the range to the target is not known.
- (iii) Flash-back and after-burn.
- (iv) The effects of wind and drift on the H.E.S. shell.
- (v) Confirmation of effective gun life.

2. METHOD OF TEST

(i) One 120 m.m. barrel, No. L/507, modified for fume extraction, was used with breech ring No. L/322, mounted in Conqueror tank No. 40 BA 76.

(ii) Both types of ammunition were fired series for series (10 rounds per series) at each range until the dispersion increased to abnormal dimensions, indicating that the wear limit had been reached. The barrel diameter at 1" C. of R. was measured 5 minutes after the completion of each series.

(iii) Velocities of all rounds fired were obtained by 3 channel P.C.C. equipments by arrangement with C.S.R. (P. and E.E., Eskmeals). The records were corrected for the distance from the gun muzzle to midway between the sets of sky screens, and the velocities shown in the report are muzzle velocities.

(iv) Flash-back and after-burn were recorded by visual observation.

(v) The speed and direction of the wind were recorded at two points on a line parallel to the line of fire.

3. RESULTS

3.1 Results of firings for dispersion obtained until the barrel reached the normal condemning limit, i.e. mean wear (hor. and vert.) at 1" C. of R. = 0.25", are shown in Table 1 (pages 2 and 3).

Totals of ammunition fired at this stage of the trial, excluding 5 cleaner rounds (2 A.P.D.S. and 3 H.E.S.) equalled 190 rds. A.P.D.S./T. and 214 rds. H.E.S., and the dispersion of either type had not deteriorated with gun wear. The mean values for each type at each range are shown in Table 2 (page 4).

Arising from the A.P.D.S. firings the most notable feature that can be attributed to the lanoline treatment is the complete absence of "wild rounds" and the extremely small number of rounds rejected during analysis. Only one miss was recorded - this occurred when the gun wear had exceeded the normal condemning limit - and two strikes were rejected because of their position relative to the m.p.i. of the series. The dispersion of 0.364 (mean hor. and vert. at all ranges) or 1.22 min. S.D.

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Table

Dispersion Values are Shown

Type of Ammunition	A.P.D.S. Records								Char Ten OF
	1,000 Yds.		1,500 Yds.		2,000 Yds.		Mean M.V. (f.p.s.)	Mean Dia. 1" C. of R. (ins.)	
	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.			
A.P.D.S./T.	0.25	0.29					4780	4.718	57
H.E.S.									
H.E.S.									
A.P.D.S./T.			0.25	0.28			4779	4.735	57
H.E.S.									
A.P.D.S./T.					0.26	0.22	4800	4.751	65
H.E.S.									
A.P.D.S./T.	0.25	0.27					4707	4.767	55
A.P.D.S./T.			0.65	0.6			4715	4.784	59
H.E.S.									
H.E.S.									
A.P.D.S./T.					0.6	0.41	4697	4.800	55
H.E.S.									
A.P.D.S./T.	0.39	0.34					4657	4.816	61
A.P.D.S./T.			0.47	0.44			4672	4.833	60
H.E.S.									
H.E.S.									
A.P.D.S./T.					0.25	0.34	4656	4.845	60
A.P.D.S./T.	0.25	0.26					4616	4.858	64
H.E.S.									
A.P.D.S./T.			0.26	0.34			4665	4.873	56
H.E.S.									
A.P.D.S./T.					0.5	0.43	4669	4.884	62
H.E.S.									
A.P.D.S./T.	0.39	0.38					4661	4.895	60
H.E.S.									
A.P.D.S./T.			0.32	0.34			4662	4.905	63
H.E.S.									

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Table 1

Values Shown in Mils. (M) S.D.

	H. E. S. Records								
Charge Temp. °F.	1,000 Yds.		1,500 Yds.		2,000 Yds.		Mean M. V. (f.p.s.)	Mean Dia. 1" C. of R. (ins.)	Charge Temp. °F.
	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.			
57	0.2	0.1	0.28	0.25			2542 2559	4.718 4.718	60 61
57					0.39	0.31	2587	4.735	63
65	0.28	0.33					2550	4.752	53
55									
59			0.45	0.24			2544	4.786	50
					0.28	0.24	2554		50
55									
	0.24	0.27					2532	4.801	62
61									
60			0.39	0.33			2533	4.834	55
					0.16	0.13	2566	4.836	56
60									
64	0.23	0.16					2569	4.860	64
56									
			0.24	0.32			2521	4.873	56
62					0.29	0.23	2483	4.884	63
60	0.27	0.32					2500	4.895	61
63			0.21	0.25			2524	4.905	65

2.

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Table 1 (Cont'd)

Type of Ammunition	A.P.D.S. Records										H.E.S. Records																
	1,000 Yds.			1,500 Yds.			2,000 Yds.			Mean M.V. (f.p.s.)	Mean Dia. 1" C. of R. (ins.)	Charge Temp. °F.	1,000 Yds.			1,500 Yds.			2,000 Yds.			Mean M.V. (f.p.s.)	Mean Dia. 1" C. of R. (ins.)	Charge Temp. °F.			
	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.	Hor.				Vert.	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.								
A.P.D.S./T.							0.28			4685	4.917	67															
H.E.S.										4562	4.925	55															
A.P.D.S./T.	0.27	0.32																									
H.E.S.																											
A.P.D.S./T.				0.28	0.32					4589	4.936	59															
H.E.S.																											
H.E.S.																											
H.E.S.																											
A.P.D.S./T.	0.36	0.39								4580	4.945	61															
H.E.S.																											
A.P.D.S./T.				0.35	0.61					4583	4.954	60	0.19	0.19													

* 24 rounds H.E.S. fired at $44\frac{1}{2}$ degrees to obtain data on maximum range.

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Table 2

Type of Ammn.	1,000 Yds.		1,500 Yds.		2,000 Yds.		Mean all Ranges	
	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.
A.P.D.S./T.	0.32	0.32	0.37	0.39	0.38	0.34	0.36	0.35
H.E.S.	0.26	0.22	0.31	0.26	0.29	0.21	0.29	0.23

compares with the result obtained in 1953 and contained in F.V.R.D.E. Report No. A.R. 145, when the mean value for case rammed projectiles was 1.3 min S.D., and when a comparatively large number of "wild rounds" occurred. During firings with A.P.D.S. the strike on ground of the discarded pot was recorded for all rounds; the zones are about the same as measured during other firings and no correlation exists between strike of pot and strike of core. Another apparent important factor is the dispersion of the H.E.S. shell. Its mean value (hor. and vert. at all ranges) is recorded as having an S.D. of 0.26 m; this represents a deterioration of about 50% on the 1953 value of 0.6 min. (0.18 m) S.D. However, it is doubtful if this increase in dispersion will affect the probability of hitting targets at unknown ranges.

3.2 Continued Firings

Since the barrel wear of 0.25" had not affected the dispersion of either type of ammunition, firings were continued to determine what further useful life remained in the gun barrel. The results of these further firings are shown in Table 3 (continuing from Table 1).

Table 3

Type of Ammn.	1,000 Yds.		1,500 Yds.		2,000 Yds.		Mean M.V. f.p.s.	Mean (ins.) at 1 in. C. of R.	Ch. Temp. °F.
	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.			
H.E.S.			0.26	0.29			2510	4.954	50
A.P.D.S./T.					0.43	0.34	4619	4.964	55
H.E.S.					0.3	0.24	2528	4.964	58
A.P.D.S./T.	0.91	0.55					4568	4.972	59
H.E.S.	0.3	0.32					2490	4.972	54
H.E.S.			0.23	0.21			2506	4.972	55
H.E.S.					0.7	0.25	2521	4.973	55
A.P.D.S./T.	0.38	0.52					N.R.	4.974	50
H.E.S.	5/10 missed target.						N.R.	4.974	51

5 rounds.

It is apparent from the dispersion values shown in Table 3 that very little useful life remains in the 120 m.m. tank gun barrel when the bore diameter at 1" C. of R. exceeds 4.95". However, before the last series,

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in which five rounds (H.E.S.) missed the target, the gun had fired another 25 rds. A.P.D.S./T. and 50 rds. H.E.S., making totals (fired for dispersion) of 215 rds. A.P.D.S./T. and 264 rds. H.E.S.

3.3 Effect of Gun Wear on Position of Mean Point of Impact

3.3.1 Effects on H.E.S. Ammunition

The mean points of impact of all series of H.E.S. rounds fired have been plotted (figure 1) in order to determine displacement due to gun wear throughout the life of the gun. It will be seen that (although not theoretically justifiable) it is possible to draw a straight line with the same slope through each set of values at the three ranges (1,000, 1,500, 2,000 yds.). This leads to a simple method of compensating the gunner's sight for gun barrel wear by offsetting the sight datum of the H.E.S.H. scale by a fixed amount, according to the bore measurement at 1" C. of R. Thus if the angles of tangent elevation for a new gun are taken as:-

at 1,000 yds. 29 min. (8.6 μ)
at 1,500 yds. 48 min. (14.2 μ)
at 2,000 yds. 72 min. (21.3 μ)

and a correction equal to 1.5 min. per 0.1" wear at the C. of R. is applied, adequate compensation will be provided throughout gun life.

In the absence of any correction for this drop of the m.p.i. of H.E.S.H. due to gun wear, the effects on the probability of hitting with the first round of an engagement will be very serious. The percentage probabilities are shown in Table 4. The factors and their values used in the calculations are: gun dispersion, Hor. 0.29 μ vert. 0.23 μ S.D. (as found during this trial); incidental errors, hor. 0.29 μ vert. 0.34 μ S.D. rangefinder/operator error 15 R² S.D. Thus the values shown are those expected under ideal range conditions.

Table 4

Probability of Hitting a 7' 6" Sq. Target with the
First Round of a H.E.S.H. Engagement

Target Range	1,000 Yds.	1,500 Yds.	2,000 Yds.
New gun.	99%	84%	51%
0.1" wear.	93%	64%	40%
4th qtr. gun.	57%	27%	13%
New gun range visually estimated.	51%	20%	2%

3.3.2 Effects on A.P.D.S./T. Shot

An examination of the positions of the mean points of impact of all series of A.P.D.S./T. shot - up to the point when gun wear at 1" C. of R. had reached 0.25" - shows that there is no effect due to gun wear, and the probability of hitting with A.P.D.S./T. shot should be the same throughout gun life. However, it was found that the smallest mean displacement of the m.p.i. is achieved when the angles of tangent elevation are:-

at 1,000 yds. 7 min. Obtained from 8 series. Series to series variation = 1 min. S.D.
at 1,500 yds. 11 min. Obtained from 7 series. Series to series variation = 0.53 min. S.D.
at 2,000 yds. 15 min. Obtained from 5 series. Series to series variation = 0.64 min. S.D.

The mean points of impact of all series are plotted in figure 2.

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4. FLASH-BACK AND AFTER-BURN

Flash-back is defined as the emission of flames from the chamber when the breech opens and the empty cartridge case is ejected on semi-automatic (S.A.) action during run-out of the gun after firing.

After-burn is defined as flaming in the ejected cartridge case; it may persist for several minutes.

Neither are considered very seriously by the R.A.C., although on occasions of severe flash-back the appearance can be alarming. Severe after-burn might present a more serious hazard, but this is eliminated in Conqueror tank as the empty cases from the breech are ejected automatically from the fighting compartment to outside the tank.

With guns designed and fitted for fume extraction, instances of both flash-back and after-burn have decreased considerably, and the records made during this trial show that only one case of flash-back (with A.P.D.S.) and eleven cases of after-burn (6 with A.P.D.S. and 5 with H.E.S.) were experienced.

5. THE EFFECTS OF WIND AND DRIFT ON H.E.S. SHELL

The speed and the direction of the wind relative to the line of fire were recorded throughout the trial at two points on a line very close to and parallel with the line of fire. The records for all rounds of H.E.S. have been resolved and the crosswind components (mean of the two recording positions) have been plotted and are shown in figure 3.[‡] The effects are summarised in Table 5 below.

Table 5

Displacement in Inches From Aiming Point

Range	1,000 Yds.	1,500 Yds.	2,000 Yds.
10 f.p.s. crosswind.	27	60	103
Drift.	33	60	120

5.2 Effects of Wind and Drift on A.P.D.S./T. Shot

The results of the analysis of the lateral displacement of A.P.D.S./T. shot due to crosswind and drift show inconsistency to such a degree that they are not sufficiently reliable to warrant publication. The results will, however, remain in the records at F.V.R.D.E.

6. CONFIRMATION OF GUN LIFE

As previously stated, the normal condemning limit for the 120 m.m. tank gun is 0.25" wear at 1" C. of R. Measurements taken during this trial, 5 mins. after the completion of each series, have been plotted against the mean muzzle velocity recorded for each series fired, and figure 4 shows that the maximum loss of muzzle velocity due to wear of gun is about 250 f.p.s. with A.P.D.S. shot and about 100 f.p.s. with H.E.S. shell. The firings confirm that little useful life may be expected from the 120 m.m. tank gun after wear at 1" C. of R. reaches 0.25", although in this trial some 25 rounds of A.P.D.S. and 50 rounds of H.E.S. were fired after the wear figure had been reached and before the target was missed due to the erratic trajectory of the rounds.

7. CONCLUSIONS

7.1 The dispersion (mean horizontal and vertical) of the lanoline-treated A.P.D.S. shot has an S.D. of 0.36 mils. or 1.22 min.; it shows little variation between 1,000 yds. and 2,000 yds. With A.P.D.S. shot

[‡] The plots shown by a + sign are the results of firings of another trial made at 1,500 yds. using a different gun.

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having lanoline-treated core tapers, the "wild round" is very seldom experienced.

7.2 The dispersion (mean horizontal and vertical) of the H.E.S. shell has an S.D. of 0.26 mils. or 0.9 min.; considering the other errors in tank gunnery this accuracy appears to be quite adequate.

7.3 The effect of gun barrel wear on the vertical displacement of A.P.D.S. shot is insignificant, but with H.E.S.H. shell large vertical displacements may be expected during engagements at 2,000 yds. when the barrel wear reaches 0.2" at 1" C. of R. In the absence of any compensation for this it will have a serious effect on the probability of hitting the standard size target with the first round of an H.E.S.H. engagement, when the range is determined using an optical rangefinder having an error of $15R^2$.

7.4 Flash-back and after-burn do not present a hazard when firing the 120 m.m. gun in Conqueror tank.

7.5 The results obtained on this trial using H.E.S. (i.e. the inert filled) shell suggest that:-

(i) the lateral displacement of the H.E.S.H. shell due to a 10 f.p.s. crosswind should be 27" at 1,000 yds., 60" at 1,500 yds. and 103" at 2,000 yds, and

(ii) the lateral displacement of the H.E.S.H. shell due to drift should be 33" at 1,000 yds., 60" at 1,500 yds. and 120" at 2,000 yds.

7.6 The results derived from the records made to determine the effects of crosswind and drift on the lateral displacement of A.P.D.S./T. shot were too inconsistent, and no reliable values were obtained.

7.7 The normal condemning limit for the 120 m.m. tank gun should remain at the present measurement of 4.95" at 1" C. of R. At this stage of wear it was found that the drop of muzzle velocity was about 250 f.p.s. when firing A.P.D.S. shot and 100 f.p.s. when firing H.E.S. shell, both projectiles being case rammed.

8. RECOMMENDATIONS

To compensate for the effect of gun barrel wear on the displacement of H.E.S.H. shell, it is recommended that the H.E.S.H. range scale datum mark in Conqueror, F.V.214, be modified by the addition of suitable further markings below it, the markings representing a correction of 1.5 min. per 0.1" of barrel wear.

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APPENDIX 1

Particulars of Ammunition

A.P.D.S. (Lanoline-treated) Ammunition

Cartridges

Cartridge Q.F. 120 m.m. Tank Gun.
Propellant NQ/M.071 Lot B.S.21832.
N/W = 29 lb. 4 ozs. 0 drms.
A/W = 29 lb. 0 ozs. 6 drms.

Date of proof 10.11.55 Inchterf.

Fitted with primer No. 33 Lot 41 and
igniter cartridge X1.E1 filled G.D.1/55.

Shot

A.P.D.S./T. Makes RLB/53 to D2/L/8345/GE.
Filled to 1A/1906. Fitted with tracer
No. 35 Mk. 1. Lot 5 Cy. 7/54. From
accepted Service stock.

Packed in C.351 = 300. Marked F.V.R.D.E. - 2/88/311

H.E.S. Ammunition

Up to Series 34.

Cartridge

D2/L/10986/GF

Propellant NH.033 Lot K.A.1034

Weight of charge 11 lb. 10 ozs.

Shell

02/88/202

Cy. 155

Beyond Series 34.

Cartridge

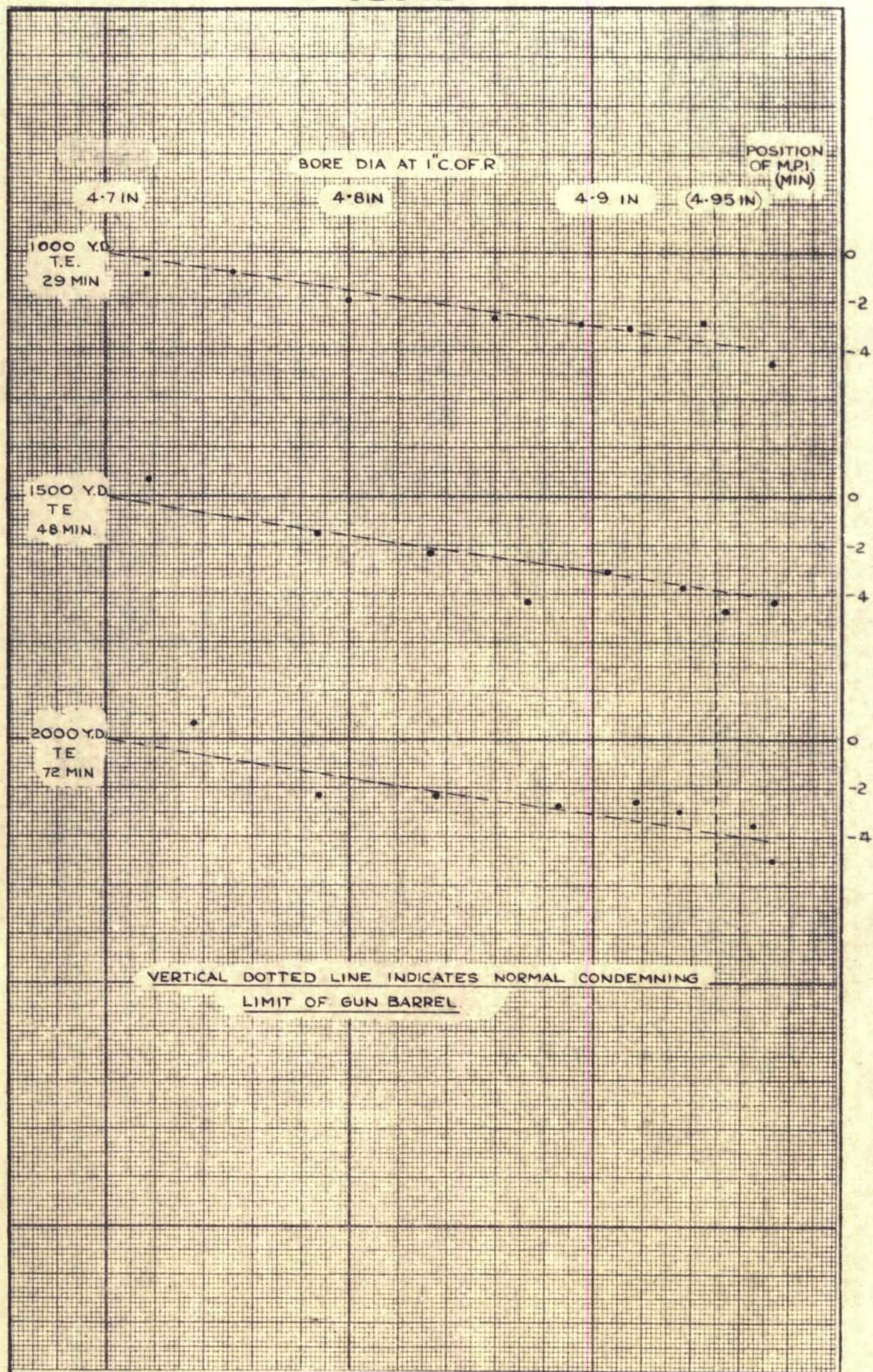
Propellant NH.C33 Lot K.A.1031.

Weight of charge 11 lb. 9 ozw. 7 drms.

Shell

L1.TK. Prac. L1-A2.

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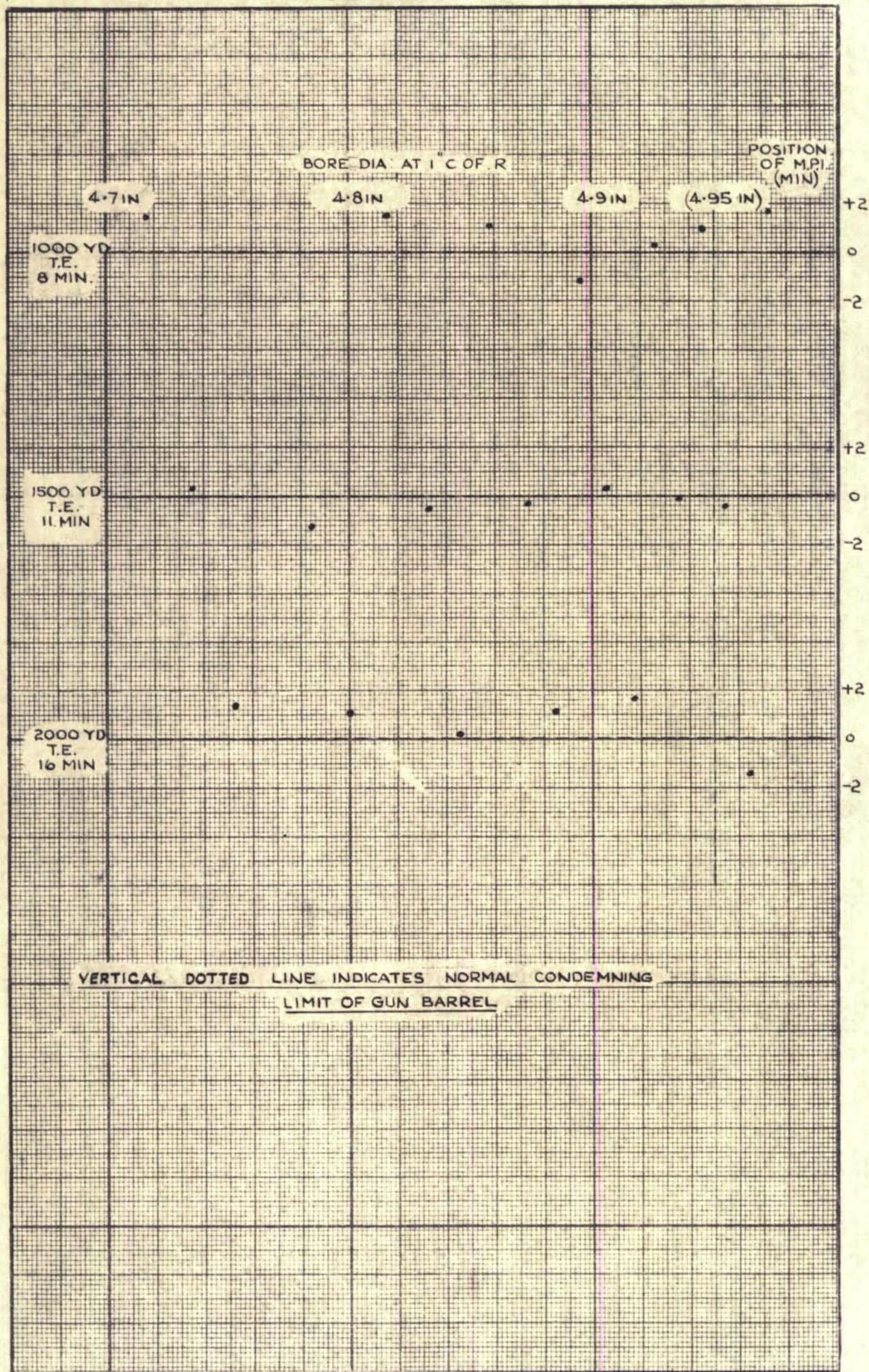
DISPLACEMENT OF M.P.I. WITH WEAR OF GUN BARREL
H.E.S. PROJECTILE.

120^M. GUN IN CONQUEROR

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FIGHTING VEHICLES RESEARCH AND
DEVELOPMENT ESTABLISHMENT.

FIG. N° 1



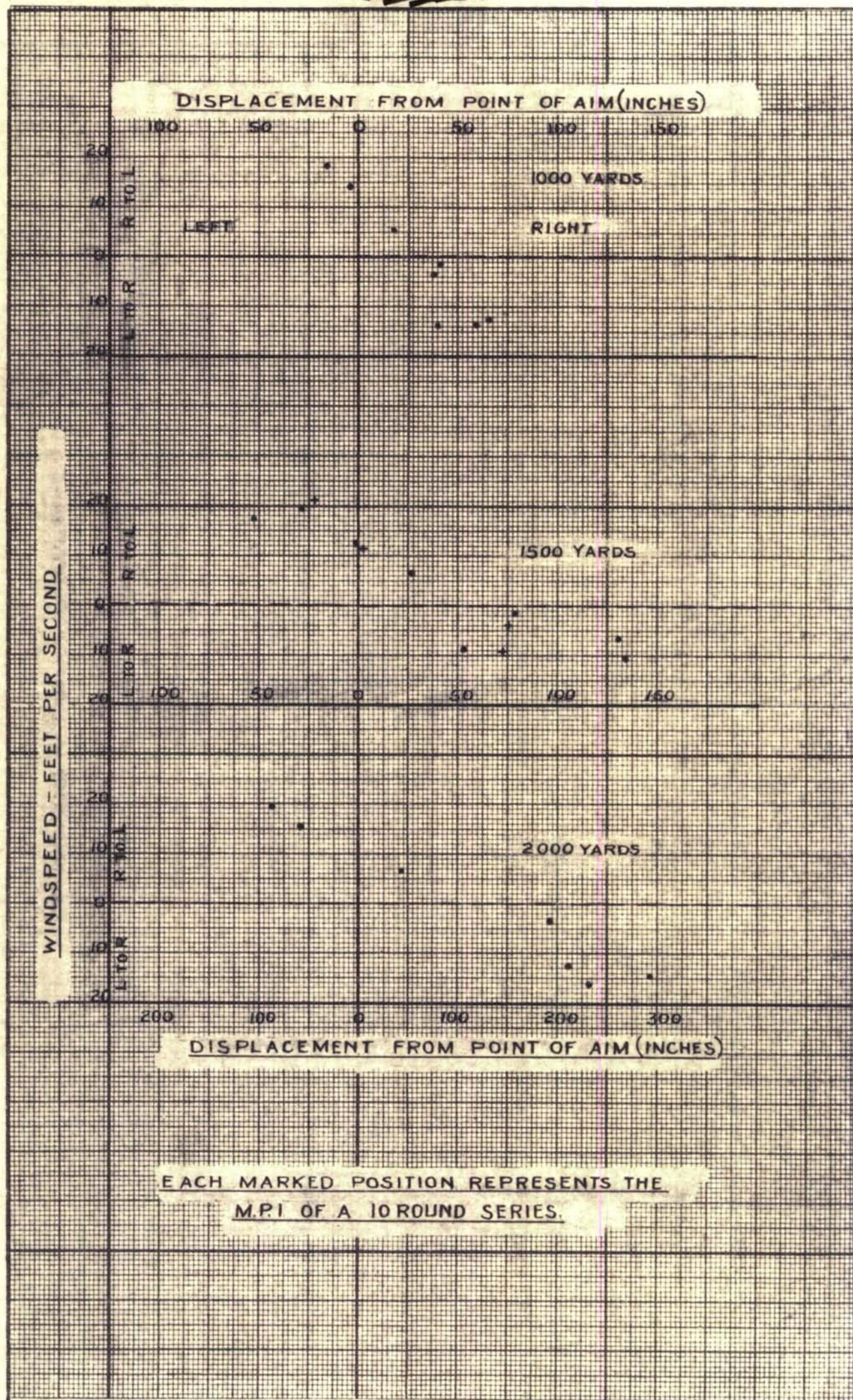
DISPLACEMENT OF M.P.I. WITH WEAR OF GUN BARREL
A.P.D.S/T. SHOT

120^M/_M GUN IN CONQUEROR

FIGHTING VEHICLES RESEARCH AND
DEVELOPMENT ESTABLISHMENT.

REPORT N°
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FIG. N° 2



EACH MARKED POSITION REPRESENTS THE
M.P.I. OF A 10 ROUND SERIES.

EFFECTS OF CROSSWIND & DRIFT
ON H.E.S. SHELL

UNCLASSIFIED

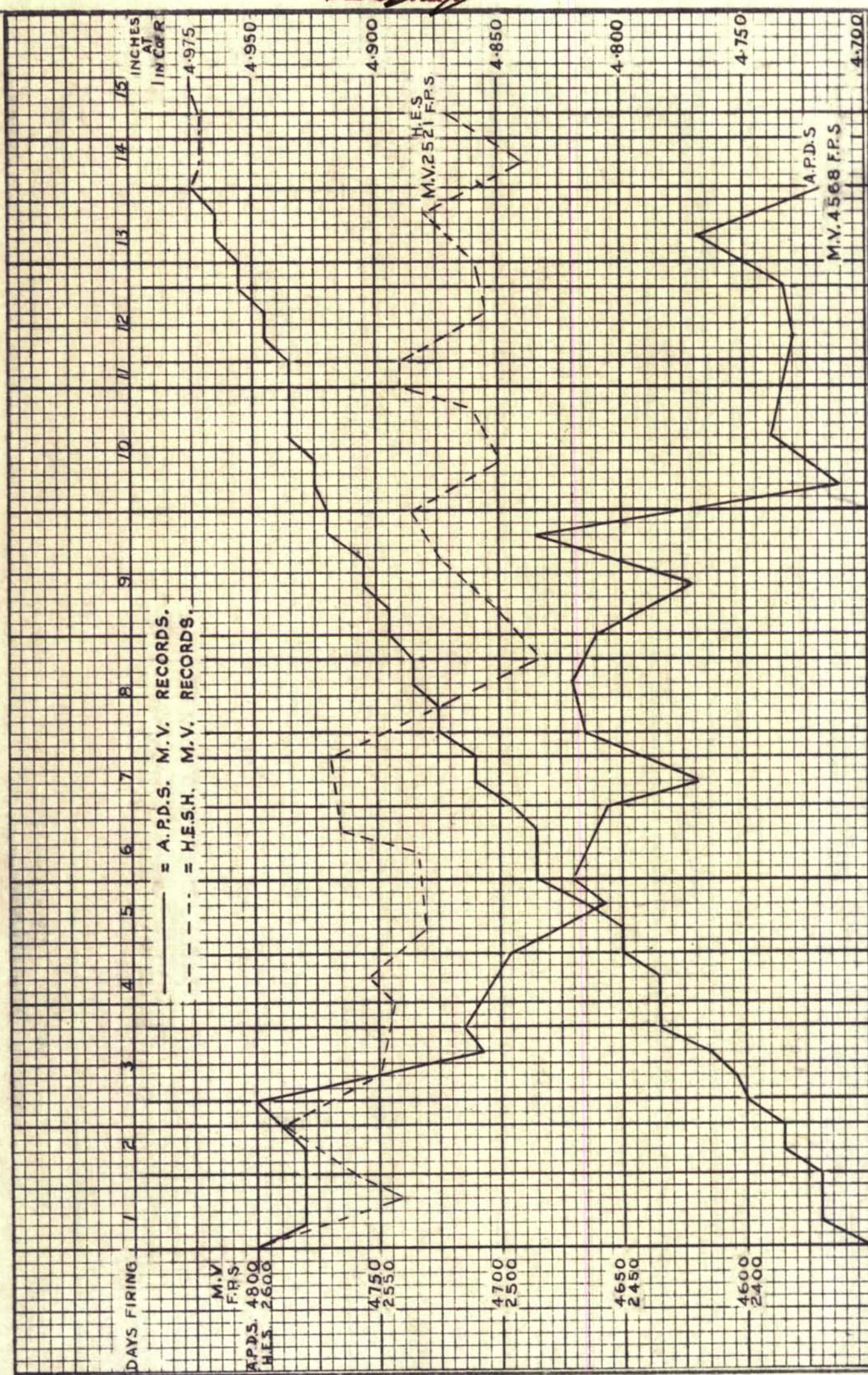
120^M GUN IN CONQUEROR.

REPORT N°

T.R.7.

FIGHTING VEHICLES RESEARCH AND
DEVELOPMENT ESTABLISHMENT.

FIG. N° 3.



RECORD OF BORE MEASUREMENTS AT 1 IN COFR TAKEN 5 MINUTES AFTER COMPLETION OF EACH SERIES. MUZZLE VELOCITIES SHOWN ARE THE MEAN VELOCITIES FOR EACH SERIES.

120^M GUN IN CONQUEROR.

REPORT NO
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